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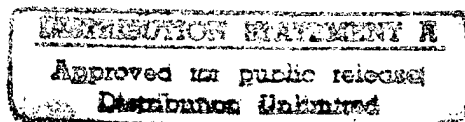
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Dear Madam/Sir:

Enclosed is a copy of the Final Report for ONR Grant N/N00014-96-1-0503, APPLICATION AND THEORY OF RANDOM SETS. The Principal Investigators are Avner Friedman, John Goutsias, Ronald Mahler and Hung T. Nguyen. A proceedings volume which will be published by Springer-Verlag is under preparation.

Sincerely,

Patricia V. Brick
Patricia V. Brick



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APPLICATION AND THEORY OF RANDOM SETS
FINAL REPORT

Period Covered by This Report: 6/1/96-12/31/96

AVNER FRIEDMAN

January 31, 1997

OFFICE OF NAVAL RESEARCH

ONR Grant N/N00014-96-1-0503

INSTITUTE FOR MATHEMATICS AND ITS APPLICATIONS
514 Vincent Hall
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Minneapolis, Minnesota 55455

FINAL REPORT

Title of Project: **Application and Theory of Random Sets**

ONR Grant Number: N/N00014-96-1-0503

Period Covered: 6/1/96-12/31/96

Principal Investigators: Avner Friedman, John Goutsias, Ronald Mahler and Hung T. Nguyen

Author of the Report: Ronald Mahler

I. Summary of Problem Studied.

On August 22-24, 1996, an international group of researchers convened under the auspices of the Institute for Mathematics and Its Applications (IMA), in Minneapolis, Minnesota, for a scientific workshop called "Application and Theory of Random Sets." The workshop was jointly sponsored by the Office of Naval Research, the Army Research Office, and the Eagan, Minnesota Engineering Center of Lockheed Martin Tactical Defense Systems. The scientific organizers were John Goutsias (Johns Hopkins), Ronald Mahler (Lockheed Martin), and Hung T. Nguyen (New Mexico State). Prof. Avner Friedman, Director of the IMA, was the institutional organizer.

This was apparently the first scientific gathering in the United States devoted primarily to the subject of random sets and allied concepts. The immediate purpose of the workshop was to bring together researchers and other parties from academia, industry, and the U.S. Government who were interested in the potential application of random set theory to practical problems of both industrial and government interest. The long-term purpose of the workshop was expected to be enhancement of imaging, information fusion, and expert system technologies and the more efficient dissemination of these technologies to industry, the U.S. Government, and academia.

To accomplish these two purposes we tried to bring together, and encourage creative interdisciplinary cross-fertilization between, three communities of random-set researchers which seem to have been largely unaware of each other: theoretical statisticians, those involved in imaging applications, and those involved in information fusion and expert system applications. Rather than "rounding up the usual suspects," we attempted to mix experienced researchers and experienced practitioners having complementary interests but who, up until that time, had not had the opportunity for scientific interchange.

II. Summary of Most Important Results.

The approximately forty people who attended the workshop constituted an unusually diverse group of researchers: theoretical statisticians; academics involved in applied research; personnel from government laboratories such as USAF Wright Labs and Naval Research and Development; and industrial R&D engineers from large and small companies such as Lockheed Martin, Raytheon, Texas Instruments, Oasis Research, Data Fusion Corporation, and Applied Biomathematics. The seventeen papers presented at the workshop reflected this diversity. Some were tutorial in nature, some were detailed mathematical treatises, some were summary overviews of an entire subject, and still others were investigations rooted in practical engineering intuition. Three of these papers were presented by plenary speakers of world standing in the field: Ilya Molchanov (University of Glasgow), Ulrich Höhle (Bergische Universität), and Jean-Yves Jaffray (University of Paris-VI). As planned, the workshop was organized into three sessions, devoted respectively to the following topic areas and each chaired by one of the scientific organizers:

- August 22: *Image Modeling and Analysis* (J. Goutsias)

- August 23: *Information Fusion and Expert Systems* (R. Mahler)
- August 24: *Expert Systems and Theoretical Statistics* (H.T. Nguyen)

Besides the usual question-and-answer sessions, at the end of each session a block of time was set aside to facilitate cross-disciplinary interaction between all participants. Major outstanding problems and gaps were aired during these interchanges.

The purposes of the workshop were achieved. A proceedings is currently in the process of preparation, and will be published by Springer-Verlag under the auspices of the IMA. A list of participants was made available, thus facilitating future interactions between the three communities of researchers.

The workshop also provided an effective forum for interchange between the mathematicians, scientists, and engineers present. For example, the so-called "fast Moebius transform" is well-known in the expert systems community (where it originated). Until this workshop, stochastic geometry researchers had been completely unaware of it. Similarly, data fusion researchers had been unaware of fast techniques for computing the Hausdorff distance—techniques well-known to the stochastic geometry community.

III. Manuscripts received for the IMA Volumes in Mathematics and its Applications on "Application and Theory of Random Sets" to be published by Springer-Verlag, New York.

- Geometric structure of lower probabilities by Paul K. Black
- Cramér-Rao type bounds for random set problems by Fred E. Daum
- Extension of relational and conditional event algebra to random sets with applications to data fusion by I.R. Goodman and G.F. Kramer
- On the maximum of conditional entropy for upper/lower probabilities generated by random sets by Jean-Yves Jaffray
- Random sets in data fusion - multi-object state-estimation as a foundation of data fusion theory by Shozo Mori
- Some static and dynamic aspects of Robust Bayesian theory by Teddy Seidenfeld
- Laws of large numbers for random sets by Robert L. Taylor

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13. ABSTRACT (Maximum 200 words)

The workshop brought together theoretical statisticians, experts in imaging applications and researchers involved in data fusion. The participants came from universities, industry and government. The topics discussed included morphological analysis of random closed sets and their optimal filtering, statistical problems for random sets, conditional entropy for random sets, tracking problems and data fusion methodologies, belief measures, limit theorems of random sets, random sets in decision making, static and dynamic aspects of Bayesian theory, and optimal granulomeric filtering in the signal-union clutter. There were many discussions, as well as interactions among people that have not met before. Proceeding of the workshop is under preparation.

14. SUBJECT TERMS

imaging applications, data fusion, morphological analysis, random closed sets, optimal filtering, conditional entropy, Bayesian theory

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